5309 Shilshole Avenue NW
Suite 200
Seattle, WA 98107
206.789.9658 phone
206.789.9684 fax

esassoc.com

memorandum

date	August 27, 2020
to	Thom Fischer, Tollhouse Energy Company
cc	Shane Cherry, Shane Cherry Consulting
from	Paul Schlenger and Luke Johnson, Environmental Science Associates
subject	Evaluation of the Potential Effects of Field Turf on Fish in the Puyallup River

At the request of Electron Hydro, this evaluation has been prepared to examine the potential fish effects of the introduction of the Field Turf into the Puyallup River. The Electron Hydro diversion is located at river mile 40 of the Puyallup River, approximately 18 river miles southeast (upstream) of the City of Orting. The issue arose during construction of repairs to the Electron Hydro diversion and spillway replacement which led to approximately 617 square yards (sq. yds.) of Field Turf being washed downstream of the diversion. A full description of the washout and ensuing actions to remove the materials and observe the Field Turf dispersal patterns is contained in the Material Removal Plan Draft document prepared by Shane Cherry Consulting on August 13, 2020. A summary of the most pertinent aspects of that report for evaluating the potential effects to fish resources is as follows:

- The Field Turf used was older material (i.e., several years old) previously used in the area for a soccer field or similar purpose.
- The Field Turf includes plastic grass yarn with crumb rubber and graded silica sand as loose infill.
- When washed away from the site, much or all of the crumb rubber particles separated from the plastic grass mats.
- It is estimated that between 4 to 6 cubic yards of crumb rubber was released to the river in particles with typical grain size of 1.19 mm.
- Crumb rubber is slightly denser than water (specific gravity 1.15), so it does not float, but it is much more mobile than natural sediments of similar size; the crumb rubber may settle out in low energy areas, but is expected to be readily entrained and transported away when flows increased.
- Considering the site conditions and field observation, crumb rubber particles were rapidly dispersed downstream and did not form identifiable accumulations, rather trace amounts of crumb rubber (5 to 20 individual grains) were observed at locations ranging from the construction site to approximately 19 miles

downstream (no observations made further downstream). Those observations were made on August 9 and 10, 2020, 10 days after the material was released.

- Field Turf pieces were mostly placed in approximately 25 sq. yd. sections (8 ft. x 28 ft.) but some smaller cut pieces were also placed; cut or torn pieces may be smaller than 2 sq. yd.

- Approximately 67 sq. yds. of Field Turf remain in the river after initial response actions removed 550 out of the 617 sq. yds. originally washed out.

Fish Resources in the River

The Puyallup River supports populations of several resident and anadromous salmon and trout species, including three species protected under the Endangered Species Act: Chinook Salmon, Steelhead, and Bull Trout. Other salmon and trout species present are Coho, Chum, and Pink Salmon, and Coastal Cutthroat Trout (Puyallup and Chambers Salmon Recovery Lead Entity 2018). These salmon and trout species have varied life history strategies such that in all months of the year there are juveniles rearing and adults migrating or spawning. Salmon spawning is documented in parts of the Puyallup River downstream of the Electron Hydro diversion by Winter Steelhead, Coho Salmon, and Pink Salmon (Puyallup and Chambers Salmon Recovery Lead Entity 2018). Given this spawning activity, there are also salmon and trout eggs incubating in the river gravels during all months of the year.

There are also several other fish species in the Puyallup River, including River Lamprey, Reticulate Sculpin, Shorthead Sculpin, Prickly Sculpin, Mountain Whitefish, Largescale Sucker, Speckled Dace, and Longnose Dace. Many of these species are bottom-oriented species whose habitat use includes low energy pools as well as riffles.

Chemical Composition of Field Turf Materials

The Material Safety Data Sheet (MSDS) published by the Field Turf manufacturer/distributor in 2016 (included in Material Removal Plan as an appendix) indicates that the plastic grass yarn consists of linear low-density polyethylene (LLDPE). The chemical characterization of the polymer is LLD Ethylene/1-Hexene Copolymer, CAS-No. 25213-02-9. The MSDS states that LLDPE is "not expected to be harmful to aquatic life," nor is it expected to have "significant environmental persistence or bioaccumulation." The toxicological information in the MSDS states that the "material is considered to be of little to no toxicological concern."

Crumb rubber is made from reclaimed tires. The materials in tires vary by manufacturer. In addition to varying proportions of natural or synthetic rubber, tires contain a broad range of additives are included. The chemical classes associated with car tires includes polyaromatic hydrocarbons (PAHs), phthalates, sulfenamides, guanidines, thiazoles, thiuams, dithiocarbamates, sulfur donors, phenolics, phenylenediamines and heavy metals (Halsband et al. 2020). In an investigation of tire composition from multiple manufacturers and studies, 20 different metals were detected, including zinc, copper, lead, chromium, cadmium, and arsenic (U.S. EPA & CDC/ATSDR 2019). Rhodes et al. (2012) state that tires contain approximately 1-2% zinc by weight.

Literature Review of Potential Effects

This evaluation of potential effects to fish is based on a review of readily available literature on the toxicity of the crumb rubber released to the river. This evaluation does not focus on the potential effects of the plastic grass due to the non-toxic chemical composition of the plastic grass, the limited quantity that are expected to remain in the river following continued retrieval efforts, a lack of identified research examining the plastic grass, and an expectation that the potential for effects is greater from crumb rubber.

For fish in the aquatic environment, two primary potential exposure routes were identified and researched: 1) via water quality contamination associated with leaching from the crumb rubber, and 2) ingestion of drifting crumb rubber granules in the water column and/or on the river bottom. An overview of the literature is provided on both exposure routes followed by an interpretation of the potential effects resulting from the Field Turf washed downstream into the Puyallup River.

Effects of Water Quality Contamination

Due to concerns about the potential human health risks of crumb rubber on sports fields there is an extensive library of studies investigating the potential acute, chronic, and carcinogenic effects. There has been less research on the aquatic effects of crumb rubber although there is an ongoing emphasis on studies to assess the potential effects of tire and road wear particles affecting aquatic resources. Since the tire wear particles and the crumb rubber granules are both comprised of tires, although different size particles, the tire and road wear research is relevant to this evaluation of the potential effects of crumb rubber.

Key factors in the toxicity of crumb rubber are the leachate rates and bioavailability of the constituents in the crumb rubber. On many of the topics researched related to crumb rubber leaching and potential toxicity, there are studies showing contradictory findings – some show an effect, while others find no effect. The following sections describe studies on various relevant topics.

Leaching Rates

Although the release of crumb rubber occurred in freshwater, an investigation of leaching rates in the marine environment provided useful information for this analysis. It is especially relevant given the likelihood that a substantial portion of the crumb rubber could have been transported all the way downstream to the estuary within a short period of time. Halsband et al. (2020) reported that many organic additives and metals readily leached from crumb rubber into seawater. The most abundant leachate components were benzothiazole, zinc, iron, and cobalt while polyaromatic hydrocarbons (PAHs) and phenolic compounds were also detected. Halsband et al. (2020) found that the duration of active leaching of organic compounds diminished within days, whereas zinc continued to leach out throughout the 30-day study period. This is consistent with the results of Rhodes et al. (2012) the extended leaching of zinc did not significantly deplete the zinc concentrations in tire rubber and therefore zinc is expected to continue to leach into water over an extended period of time.

Age of Crumb Rubber Affecting Leaching Rates

The overall age and weathering of the crumb rubber material can affect the leaching rates and potentially toxicity. Verschoor (2015) reviewed literature and found that because rubber is susceptible to aging, weathering affects zinc emissions from tires. Birkholz et al (2003) reported that toxicity declines through weathering or extended exposure to surrounding environment. Authors found that toxicity to aquatic organisms disappeared when tire crumbs had aged three months (i.e., greatest toxicity soon after crumb rubber initially placed on soccer field).

Crumb Rubber Particle Size Affecting Leaching Rates

Halsband et al. (2020) found that the size of the crumb rubber particle affected the amount of metals released, but did not affect organic chemicals. All metals except lead and chromium exhibited an increase in leachate concentration as crumb rubber particle size decreased. Rhodes et al. (2012) had the same finding for zinc, but there is other literature indicating that leaching rates of metals are independent of crumb rubber granule size (Selbes et al. 2015).

Water Quality Toxicity in Freshwater

There are studies showing results on both sides of the issue of whether crumb rubber poses a threat to water quality (Coastal Marine Resource Center [CMRC] 2008). Regarding the bioavailability of the leachate components, Redondo-Hasselerharm et al. (2018) documented that only small fractions of the heavy metals and PAHs were bioavailable for freshwater benthic macroinvertebrates. Redondo-Hasselerharm et al. (2018) found that car tire particles did not negatively affect four benthic invertebrates (amphipods, isopods, and two species of worms) in laboratory study even at concentrations of 10% sediment dry weight. The authors concluded that the car tire leachate presented a low risk to freshwater benthic invertebrates. However, the authors also pointed out that potential long-term effects caused by the slow release and gradual environmental increase of bioavailable zinc and other substances caused by aging of rubber particles is possible although not investigated in their study. In an investigation of acute toxicity to an alga, an invertebrate cladoceran, and a fish (Fathead Minnow) from tire and road wear particles, Marwood et al. (2011) concluded the materials should be considered low risk to freshwater aquatic systems under acute exposure scenarios.

Water Quality Toxicity in Seawater

Halsband et al. (2020) reported that marine copepods exposed to high leachate concentrations exhibited high mortality within 48 hours. The authors were not able to establish which components of the leachate were driving the observed toxicity.

In contrast, Hartwell et al. (2000) report that toxicity has been shown to decrease as salinity increases, suggesting that tire leachate is likely a greater threat in freshwater systems. Toxicity of leachates decreased with increasing salinity up to 15 ppt with no significant change at higher salinities. The decrease in toxicity is probably due to interaction of sea salts and the toxic constituents.

Effects of Ingestion

Given the size (1.19 mm diameter), color (black), and slightly negative buoyancy that is readily transported by water or deposited on the surface in low energy areas, the crumb rubber particles may potentially be eaten by fish in freshwater or marine environments. When mistaken as food, the crumb rubber could potentially create blockages in the esophagus and the intestinal tract of smaller fish and introduce harmful toxins into their system; each with potentially lethal effects (CMRC 2008). Additionally, by ingesting the pellets, the fish can potentially feel artificially satiated and suffer from reduced energy reserves (CMRC 2008).

LaPlaca and van den Hurk (2020) found that two estuarine fish species, Mummichog and Fathead Minnow, exposed to varying concentrations of crumb rubber particles ingested the material. The authors reported that the crumb rubber accumulated in the fishes' intestinal tract. In addition to some mortality when exposed to the highest concentrations in a 7-day trial, evidence of PAH leaching was documented in bile.

Potential Effects to Fish Resources in the Puyallup River

Based on this review of the literature and consideration of the characteristics and quantities of Field Turf materials released from the Electron Hydro construction site, the most likely risk of harmful effects stems from the potential ingestion of crumb rubber. For juvenile salmon, trout, and all life stages of resident fish in the river, crumb rubber granules encountered by the fish may be mistaken for prey items and consumed. As described above in studies by CMRC (2008) and LaPlaca and van den Hurk (2020), this could impair the fishes' digestive systems, remain in their systems for a long time, and release chemicals into tissues. However, the conditions in the river system may reduce the likelihood of fish encountering the crumb rubber. As described in the Material Removal Plan by Shane Cherry Consulting, the crumb rubber granules are readily transported by river flows and it appears likely that much of the material was transported out of the river in a matter of one or more days. Based on estimated water velocities, crumb rubber that remained in the water column could have reached Tacoma within 20 hours. This notion of much of the crumb rubber having been transported far downstream or even out of the river is supported by Shane Cherry's observations of only trace amounts (5 – 20 individual grains) in a series of sites downstream of the release point observed 10 days after the release. His observations were made in the 6,000 ft. river segment downstream of the construction site and at three road crossings located 10 to 19 miles downstream.

The potential for continued transport of crumb rubber particles when the river enters the estuary is expected to be reduced as the interaction of tidal water and river flows tend to reduce velocities. There is somewhat greater potential for the dispersed crumb rubber particles to be deposited in the estuary, although the channelized nature of the estuary increases the likelihood of water velocities being enough to transport the material to the delta in Commencement Bay. It is foreseeable that crumb rubber particles that deposit in the estuary or marine nearshore will occasionally get redistributed but remain in the area longer than was described in the river. High flow events during the winter months combined with low tide conditions would be expected to transport any remaining crumb rubber particles in the estuary out to the delta and deeper waters of Commencement Bay where it will deposit on the bottom and likely remain there until getting covered by future sedimentation and detritus deposition.

Given the time of the year, there are fewer juvenile salmon in the river downstream of the site than there are in earlier months of the year. For those juvenile salmon in the river in August, only a subset will be rearing in the mainstem – especially in the channelized lowermost reaches – as many will remain in the contributing rivers and creeks. This timing will reduce the likelihood of fish encountering the crumb rubber as it moves downstream.

The potential effects to fish through chemical components leaching in to the water is considered unlikely to result in concentrations that are harmful to fish. This is supported by the observations of the crumb rubber being widely dispersed shortly after getting washed into the river and no identified accumulation areas of the material.

The potential effects to fish from the plastic grass pieces is considered negligible. This conclusion is based on the fact that nearly all of the plastic grass will be removed from the river and because the plastic grass is not known to be harmful to aquatic life nor is it considered to be a toxicological concern.

In conclusion, this evaluation of the potential effects to fish from the release of crumb rubber and plastic grass from the Electron Hydro construction site finds that there is some potential for limited impacts to fish in the river and somewhat greater potential for accumulation and fish ingestion. However, since there was only 4 to 6 cubic yards released and the release point is 40 miles away, it is unlikely that any large accumulation of crumb rubber would occur. Any impacts are not expected to cause severe harm or mortality to fish.

References

Birkholz, D.A., K.L. Belton, and T.L. Guidotti. 2003. Toxicological evaluation for the hazard assessment of tire crumb for use in public playgrounds. Air & Waste Manage. Assoc. 53: 903-907.

CMRC (Coastal Marine Resource Center) 2008. The effects of crumb rubber on water quality. September 2008.

Halsband C, Sørensen L, Booth AM and Herzke D (2020) Car tire crumb rubber: does leaching produce a toxic chemical cocktail in coastal marine systems? Front. Environ. Sci. 8:125.

Hartwell, S. I., Jordahl, D. M., and Dawson, C. E. O. (2000). The effect of salinity on tire leachate toxicity. Water Air Soil Pollut. 121, 119–131.

LaPlaca, S.B., van den Hurk, P. Toxicological effects of micronized tire crumb rubber on mummichog (*Fundulus heteroclitus*) and fathead minnow (*Pimephales promelas*). Ecotoxicology 29, 524–534 (2020).

Marwood, C., B. McAtee, M. Kreider, R.S. Ogle, B. Finley, L. Sweet, and J. Panko. 2011. Acute aquatic toxicity of tire and road particles to alga, daphnid, and fish. Exotoxicol. 20(8): 2079.

Puyallup and Chambers Salmon Recovery Lead Entity. 2018. Salmon Habitat Protection and Restoration Strategy for Puyallup and Chambers Watersheds. June, 2018. 110pp.+appendices.

Redondo-Hasselerharm, P. E., De Ruijter, V. N., Mintenig, S. M., Verschoor, A., and Koelmans, A. A. (2018). Ingestion and chronic effects of car tire tread particles on freshwater benthic macroinvertebrates. Environ. Sci. Technol. 52, 13986–13994.

Rhodes, E. P., Ren, Z., and Mays, D. C. (2012). Zinc leaching from tire crumb rubber. Environ. Sci. Technol. 46, 12856–12863.

Selbes, M., Yilmaz, O., Khan, A. A., and Karanfil, T. (2015). Leaching of DOC, DN, and inorganic constituents from scrap tires. Chemosphere 139, 617–623.

Shane Cherry Consulting. 2020. Electron Hydro Diversion Repair and Spillway Replacement Project Material Removal Plan – Draft. Prepared by Shane Cherry Consulting. Prepared for Electron Hydro. August 13, 2020.

U.S. EPA & CDC/ATSDR (U.S. Environmental Protection Agency, Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry). 2019. Synthetic Turf Field Recycled Tire Crumb Rubber Research Under the Federal Research Action Plan Final Report: Part 1 - Tire Crumb Characterization (Volumes 1 and 2). (EPA/600/R-19/051).

Verschoor, A.J. 2015. Leaching of zinc from rubber infill on artificial turf (football pitches). Rijksinstituut voor Volksgezondheid en Milieu (RIVM) – National Institute for Public Health and the Environment – the Netherlands.

WDFW (Washington State Department of Fish and Wildlife). 2020. SalmonScape Database. Available at: http://apps.wdfw.wa.gov/salmonscape/map.html. Accessed August 27, 2020.